Complex diabetes screening guidelines for high-risk adolescent Aboriginal Australians: a barrier to implementation in primary health care

Andreana Manifold\textsuperscript{A,F}, David Atkinson\textsuperscript{A}, Julia V. Marley\textsuperscript{A,B}, Lydia Scott\textsuperscript{C}, Gavin Cleland\textsuperscript{C}, Paula Edgill\textsuperscript{D,E} and Sally Singleton\textsuperscript{A}

\textsuperscript{A}The Rural Clinical School of Western Australia, The University of Western Australia, PO Box 1377, Broome, WA 6725, Australia.
\textsuperscript{B}Kimberley Aboriginal Medical Services Ltd, PO Box 1377, Broome, WA 6725, Australia.
\textsuperscript{C}Western Australia Country Health Service Kimberley, PO Box 62, Broome, WA 6725, Australia.
\textsuperscript{D}Derbarl Yerrigan Health Service, 156–172 Wittenoom Street, East Perth, WA 6004, Australia.
\textsuperscript{E}Centre for Aboriginal Medical and Dental Health, The University of Western Australia (M303), 35 Stirling Highway, Perth, WA 6009, Australia.
\textsuperscript{F}Corresponding author. Email: andreana.manifold@rcswa.edu.au

Abstract. The aim of this study is to ascertain whether a simplified screening algorithm incorporating glycated haemoglobin (HbA1c) tests increases type 2 diabetes (T2D) screening in 10- to 14-year-old Aboriginal Australians presenting to primary healthcare (PHC) services. The study involved a 6-month pilot of a locally developed evidence-based screening algorithm in a remote Western Australian Kimberley town. A retrospective audit of electronic health records for the pilot period (27 June–26 December 2016) and a 6-month period before the screening algorithm was introduced (1 October 2015–31 March 2016) was conducted. Interviews were held with 30 PHC staff at participating PHC services, an Aboriginal Community Controlled Health Service (ACCHS) and a hospital-based general practice service. During the pilot, significantly more patients received an initial T2D screening test at the ACCHS (28/130 (22%) v. 50/139 (36%), \(P = 0.011\)), but there was no change at the hospital (0.02% v. 0.02%, \(P = 0.615\)). Staff feedback suggested measures to improve screening; these include simple guidelines, targeted screening, patient and staff education, point-of-care HbA1c tests and a whole-of-clinic approach to implementation. Implementing a screening algorithm for young-onset diabetes in Aboriginal Australians is challenging, but practical measures can be taken to improve screening.

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Introduction
The onset and progression of complications from type 2 diabetes mellitus (T2D), including retinopathy, neuropathy, renal disease and cardiovascular disease, can be delayed through early diagnosis and treatment (Hoy \textit{et al.} 2003; Holman \textit{et al.} 2008a, 2008b). Young-onset T2D (<25 years) is an aggressive disease that progresses more rapidly to complications than adult-onset T2D (Viner \textit{et al.} 2017). As T2D is frequently asymptomatic, screening plays an important role in its diagnosis (World Health Organization 2003; Azzopardi \textit{et al.} 2012).

Aboriginal Australian adolescents aged 10–14 years are up to eight-fold more likely to develop T2D than non-Aboriginal Australians of the same age (Australian Institute of Health and Welfare 2014). Aboriginal Australians make up over 40% of the Kimberley population (Australian Bureau of Statistics 2017). Aboriginal Community Controlled Health Services (ACCHS) in the Kimberley region have a strong focus on reducing the effect of T2D and, in collaboration with WA Country Health Services, the Kimberley ACCHS develop and implement regional guidelines for screening and management of chronic diseases (Kimberley Aboriginal Health Planning Forum 2018). Screening for T2D in adolescents with identified risk factors is recommended from age 10–14 years using a glucose-based algorithm (Kimberley Aboriginal Medical Services (KAMS) and WA Country Health Service (WACHS) 2011). Since 2015, universal screening for T2D in adults (people aged ≥15 years) using glycatied haemoglobin (HbA1c) has been recommended (KAMS and WACHS 2015). Screening with HbA1c tests in adults has been shown to be more effective than complicated glucose algorithms in the context of the Kimberley’s remote and mobile population (Marley \textit{et al.} 2015).

The Kimberley T2D guideline for adolescents aged 10–14 years has not been revised since 2011 and does not incorporate HbA1c testing (KAMS and WACHS 2011). Kimberley ACCHS staff have questioned why HbA1c is not being used for screening in younger adolescents, given its use
**What is known about the topic?**

- Young-onset type 2 diabetes (T2D) is an aggressive disease. Aboriginal Australian adolescents are more likely to develop T2D than non-Aboriginal adolescents. Screening improves patient outcomes through early detection and treatment.

**What does this paper add?**

- Glycated haemoglobin (HbA₁c) is preferred to venous glucose testing and simplifies T2D screening in Aboriginal adolescents. Guidelines incorporating point-of-care HbA₁c testing, risk-factor-targeted screening and patient and clinician education improve screening.

with adults. The use of HbA₁c as a diagnostic test for adolescents is gaining increasing recognition, and is recommended by the International Society of Paediatric and Adolescent Diabetes and the American Diabetes Association (American Diabetes Association 2010; International Diabetes Federation 2011; Viner et al. 2017). Other countries, including Canada and the UK, caution against this approach, with a handful of USA studies questioning the sensitivity of the reference ranges in adolescents (John and UK Department of Health Advisory Committee on Diabetes 2012; Kapadia and Zeitler 2012; Punthakee et al. 2018). Pragmatically, HbA₁c testing may minimise the need for recall, patient fasting and repeated blood samples, all of which are required in glucose-based algorithms, and which present barriers to young Aboriginal people receiving a timely diagnosis and access to therapy (Azzopardi et al. 2012; Marley et al. 2015).

The aims of this study were to ascertain whether a simplified T2D screening algorithm for 10- to 14-year-old Aboriginal Australians incorporating HbA₁c tests would increase the proportion of patients with identified risk factors presenting to primary healthcare (PHC) services who are screened for T2D, and to identify enablers and barriers to implementing the algorithm.

**Methods**

**Setting and patients**

This study was conducted in a remote town in the Kimberley region (Australian Government Department of Health 2016). The participants were the PHC services in this town; an ACCHS, a hospital-based general practice service (Australian Government Department of Health 2017) and remote clinics run by these organisations. The ACCHS provides comprehensive PHC for most Aboriginal people and some non-Aboriginal people in the town and in several remote communities. The hospital’s general practice service is the main PHC service for non-Aboriginal people, has some regular Aboriginal attendees and provides after-hours care. It is staffed by one full time GP with support from GPs that also work throughout the hospital. The hospital’s emergency department (ED) was included in the study due to the difficulty in differentiating general practice and ED presentations in the hospital’s electronic health records, and to the high number of presentations to the ED that are of a primary care nature.

Concurrently with this project, the participating ACCHS was also working on prevention and early intervention approaches to T2D among young people with a pilot program run by Aboriginal people (Seear et al. 2019), on improving engagement with Aboriginal youth in Derby (Warwick et al. 2019) and on improving care for Aboriginal young people with T2D (the Kimberley Investigation and Description of Young-Onset Type 2 Diabetes (KIDDY) project – see below). This pilot of the change to screening approaches for young people was focussed on the behaviour of predominantly non-Aboriginal clinical staff in initiating screening for T2D.

**Development and implementation of the screening algorithm**

A revised screening algorithm for adolescents aged 10–14 years was developed in early 2016 (Fig. 1). The algorithm adopted published recommendations from a Baker IDI Heart and Diabetes Institute position statement on T2D screening in young Indigenous Australians (Azzopardi et al. 2012), the American Diabetes Association (American Diabetes Association 2015), and the Kimberley T2D guideline for adults (KAMS and WACHS 2015). In addition, feedback on an early draft was sought from: staff at the PHC services; regional paediatricians, physicians and GPs; and the paediatric endocrinology service at the state’s tertiary children’s hospital. The key changes were: removal of an oral glucose tolerance test from the blood glucose level (BGL) pathway and the addition of a new HbA₁c pathway. The two pathways enabled clinicians to continue screening via BGL tests if preferred.

The algorithm was piloted for 6 months at participating PHC services. Measures taken to facilitate implementation of the revised algorithm for the purpose of the pilot are outlined in Box 1. Health service staff were encouraged for the duration of the pilot to use the revised algorithm instead of the existing algorithm (KAMS and WACHS 2011) and to record their reasons for screening. Implementation was assessed via a mixed-methods design, incorporating an audit of electronic medical record data to determine patterns of screening, and semi-structured interviews seeking feedback on staff satisfaction using the algorithm.

**Audit of patients screened**

The electronic medical records of each service were audited for a 6-month period before (pre-pilot: 1 October 2015–31 March 2016) and during (pilot: 27 June 2016–26 December 2016) the pilot of the algorithm to enable comparison of the proportion of patients screened. The pre-pilot period was chosen to align with the release of the updated Kimberley T2D guideline for adults on 1 September 2015 (KAMS and WACHS 2015). The pilot commenced once orientation sessions at participating sites had been completed.

Patients were included in the audit periods if they were aged 10–14 years, had at least one in-person consultation at the service during the period, and were recorded as being Aboriginal and/or Torres Strait Islander. Screened individuals were aged 10–14 years at the time of screening, had no evidence of a previous diagnosis of T2D and had a recorded test result or test request using any one of: fasting or random
If a child* possesses at least one risk factor, conduct a random capillary blood glucose level (BGL) test:
If a capillary BGL is < 5.5 mmol L\(^{-1}\), retest in a year.
If capillary BGL is ≥ 5.5 mmol L\(^{-1}\), conduct further testing via one of the following pathways:

1. Point of care capillary (POC) HbA\(_{1c}\) OR venous HbA\(_{1c}\) sample

- HbA\(_{1c}\) < 5.7% (<39 mmol mol\(^{-1}\))
- HbA\(_{1c}\) ≥ 6.5% (≥ 48 mmol mol\(^{-1}\))

- Normal
- Retest in 1 year

- Venous laboratory HbA\(_{1c}\) test**

- HbA\(_{1c}\) 5.7–6.4% (39–47 mmol mol\(^{-1}\))
- HbA\(_{1c}\) ≥ 6.5% (≥ 48 mmol mol\(^{-1}\))

- HIGH RISK DIABETES
- DIABETES DIAGNOSED

- Lifestyle modification
- Retest in 6 months

2. Fasting venous BGL AND venous HbA\(_{1c}\) sample

- Fasting venous BGL < 5.5 mmol L\(^{-1}\) OR HbA\(_{1c}\) < 5.7% (<39 mmol mol\(^{-1}\))

- Normal
- Retest in 1 year

- If the fasting BGL and HbA\(_{1c}\) test results are in agreement (i.e. both results are below a diagnostic threshold), DIABETES DIAGNOSED

- If the fasting BGL and HbA\(_{1c}\) test results are not in agreement (i.e. one result is above a diagnostic threshold but the other is not), conduct a random venous BGL OR oral glucose tolerance test regardless of capillary BGL result

- Fasting venous BGL 5.5–6.9 mmol L\(^{-1}\) OR HbA\(_{1c}\) 5.7–6.4% (39–47 mmol mol\(^{-1}\))

- HIGH RISK DIABETES
- DIABETES DIAGNOSED

- Lifestyle modification
- Retest in 6 months

Notes:
* If a child is ≥ 15, refer to the Kimberley guideline for T2D in adults.
** (1) As only one diagnostic venous laboratory HbA\(_{1c}\) test is Medicare-funded per annum, confirm diagnosis by ordering the 2nd test as ‘management’ of diabetes.
** (2) If the 1st test was a POC HbA\(_{1c}\), a venous blood sample can be taken on the same day.
** (3) Perform a Full Blood Picture at the same time to assess haemoglobin levels, as anaemia can affect the HbA\(_{1c}\) reading. If anaemia is present, treat it and retest HbA\(_{1c}\) in 6 months.

Fig. 1. Proposed algorithm for type 2 diabetes mellitus (T2D) screening in Kimberley Aboriginal Australian children aged 10–14 years. BMI, body mass index; PCOS, polycystic ovarian syndrome; HbA\(_{1c}\), glycated haemoglobin; T1D, type 1 diabetes.

Box 1. Implementation of the pilot screening algorithm

- Feedback was sought from primary healthcare (PHC) service staff on the proposed algorithm as it was being developed.
- At the Aboriginal Community Controlled Health Service (ACCHS), point-of-care (POC) glycated haemoglobin (HbA\(_{1c}\)) cartridges were ordered in to ensure adequate supply was on site for the pilot.
- Once the algorithm was finalised for the purpose of the pilot, multiple education sessions were held during routine clinical meetings to inform PHC service staff of the pilot and proposed algorithm.
- Regional paediatrician and physician teams were available throughout the pilot to provide clinical advice on the algorithm’s application.
- The primary researcher was on site at the ACCHS and hospital and was available to respond to any questions about the modified algorithm and the pilot.
- Interviews were held from October 2016 to provide staff with the opportunity to raise any early concerns about implementation of the pilot algorithm.

point-of-care (POC) BGL; fasting or random venous BGL; or POC or venous HbA\(_{1c}\).

For the ACCHS, pre-pilot and pilot data were obtained via MMEx (http://www.isahealthcare.com/Products/MMEx.aspx). For the hospital, pre-pilot data were obtained via HCRe CMS (Government of Western Australia Department of Health 2009), and pilot data were obtained via Communicare (https://www.telstrahealth.com/home/products/communicare.html). Pre-pilot general practice data included all general practice appointments and some outpatient services provided through the ED. Patient presentations to the ED that were recorded on paper files but not transcribed into Communicare, which was common for uncomplicated presentations, were not captured in the audit.

The electronic records of all individuals screened during the audit periods were reviewed to determine the reason for initial and follow-up screening, the reason if follow-up screening did not occur and which tests were used. Data extracted from MMEx and Communicare were transferred into Microsoft Excel 2010 (Microsoft Corporation, Redmond, WA, USA) for descriptive analysis. Further analyses were performed using Stata, version 14 (StataCorp, College Station, TX, USA). Screening during the pilot was compared with baseline screening rates using Fisher’s exact test. \(P < 0.05\) was considered statistically significant.
Interviews with health service staff

All clinical staff involved in T2D screening at the services were invited to participate in semi-structured interviews to assess their knowledge and satisfaction of the guideline, and to identify enablers and barriers to implementation. At the hospital, interviews were conducted with individuals or in pairs. At the ACCHS, the interviews were held as a group during routine meetings for all clinical staff. Interviews were held from October to December 2016.

Due to the practicality of interviewing busy PHC staff within an active clinical environment, responses from the interviews were not recorded electronically but were documented by the main investigator during each interview and transcribed into Microsoft Word 2010 (Microsoft) documents. Best efforts were made to record quotes accurately, but not all were verbatim. The notes were de-identified and reviewed. Key outcome measures including individual barriers and enablers to the algorithm’s implementation were identified and coded. Data segments referenced by document source were sorted by code and amalgamated into a textual database using the tabular functions of Microsoft Word 2010. The initial coding categories were further divided and refined, and a hierarchical coding scheme was developed. The main researcher and one other analysed the content of the coding categories and identified important and recurring themes, reviewed by the remainder of the research team.

Ethics approval

Following community consultation, including support from regional ACCHSs, this project was approved as part of the KIDDY project by the Research and the Maternal and Child Health subcommittees of the Kimberley Aboriginal Health Planning Forum. Ethics approval was obtained from the WA Aboriginal Health Ethics Committee (reference 661), the WA Country Health Service Human Research Ethics Committee (2015/31) and the University of Western Australia Human Research Ethics Committee (RA/4/1/7855).

Results

Proportion of patients screened

At the ACCHS, 139 Aboriginal Australians aged 10–14 years attended during the pilot period, and 130 attended in the pre-pilot period. Screening via capillary and venous blood tests increased significantly during the pilot compared with the pre-pilot (36% v. 22%, P = 0.011), and more patients received initial or follow-up venous blood tests (7/50 v. 0/28, P = 0.038). All venous blood tests conducted were HbA1c tests (Table 1). Documented reasons

Table 1. Number of patients screened as per primary healthcare (PHC) services’ electronic health records

<table>
<thead>
<tr>
<th></th>
<th>Pilot Abnormal</th>
<th>Normal</th>
<th>Pre-pilot Abnormal</th>
<th>Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients screened</td>
<td>29</td>
<td>21</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>Reason for screening</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Routine observations</td>
<td>21</td>
<td>10</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>Opportunistic with documented risk factors</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Health check (e.g. MBS 715)</td>
<td>6</td>
<td>8</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>At patient’s request</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Initial testing method</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>POC BGL (random or fasting)</td>
<td>27</td>
<td>19</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>POC random BGL and laboratory HbA1c</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Laboratory HbA1c only</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>HbA1c conducted</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Screening initiated by</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doctor</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Aboriginal Health Worker</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Nurse</td>
<td>22</td>
<td>12</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Child Healthcare Nurse</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Screened for risk factors</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Risk factors documented</td>
<td>12</td>
<td>7</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Overweight</td>
<td>8</td>
<td>5</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>1st degree relative</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Other family history of diabetes</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Acanthosis nigricans</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Doctor’s notes on day of presentation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BGL not acknowledged</td>
<td>13</td>
<td>11</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>BGL acknowledged but not discussed</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>BGL specifically noted and/or discussed</td>
<td>9</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>N/A (e.g. patient did not wait to see doctor)</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

BGL ≥5.5 mmol L⁻¹.
Initial or follow-up screening test.
Other than ‘overweight’, as per doctor’s notes on day of presentation.
for screening were most commonly routine observations initiated by a nurse, child healthcare nurse or Aboriginal Health Worker (AHW); Aboriginal health checks (e.g. Medicare Benefits Schedule item 715); and screening in response to documented risk factors (Table 1).

Seven patients received an HbA1c test during the pilot. Three were conducted in response to a random POC BGL \( \geq 5.5 \) mmol L\(^{-1}\), two in response to documented risk factors, one at the parent’s request and one as part of a health check. Of the 25 patients that had a random POC BGL \( \geq 5.5 \) mmol L\(^{-1}\) but no HbA1c test, 19 had no related documentation on file, four were placed on recall and two were asked to come back for testing at a later date. These patients either did not re-present for testing or were not tested when they did. Only one of five patients that were placed on recall had an HbA1c test conducted before the end of the pilot period.

Based on the hospital’s electronic health records, screening rates were low and there was no difference in screening during the pilot compared with the pre-pilot period (0.02% v. 0.02%, \( P = 0.615 \)). More patients were screened during general practice clinical consultations compared with ED presentations (6/29 v. 5/435, \( P < 0.001 \)). Doctors initiated all screening tests and there was no obvious pattern in the method of testing. Of the 11 patients screened, seven had a BGL or HbA1c test taken along with a range of other screening blood tests; two were at the patient or carer’s request; one had symptoms suggestive of diabetes; and one was taken as part of routine observations. There was no documentation in the notes of doctors about T2D screening in these patients, except where screening was requested.

**Staff knowledge of, and satisfaction with, the algorithm**

Sixteen interviews were conducted across both services, involving a total of 17 medical practitioners, 12 nursing staff and one medical student. Although invited, unfortunately no AHWs attended the ACCHS interviews, which were held during routine clinical staff meetings. Participants in 13 of 16 interviews indicated they supported the screening algorithm and were motivated to screen for T2D in young people. However, staff cited several barriers to implementation, with only 4 of 30 staff having used it during the pilot. Selected responses are outlined in Box 2.

The majority of staff indicated they were aware of the pilot algorithm, with the exception of staff in five interviews who had commenced a locum placement or came back from holidays after the commencement of the pilot.

With respect to barriers to implementation, staff highlighted complexity of the algorithm with the inclusion of two independent screening pathways, making the algorithm difficult to follow and to put into practice. In four interviews, staff suggested removing the fasting BGL pathway.

Another significant barrier related to apprehension about screening in young adolescents. A perception that T2D screening in 10- to 14-year-olds could pose a risk of over-screening, or unnecessary harm to patients, was expressed in half of the interviews. As a result, some staff were reluctant to perform POC or venous blood tests, or reported that patients or their parents refused testing. One locum staff member reported not using the algorithm because T2D screening in adolescents was not routinely performed in an urban setting. Other staff questioned the algorithm’s recommendations regarding patient risk factors for T2D (10 interviews), the POC BGL thresholds at which follow-up venous testing was recommended (four interviews) and the HbA1c diagnostic thresholds (two interviews). Some staff felt that patient, parent and staff concerns could be overcome through routine screening practices and education (four interviews).

Organisational practices affected screening at both locations. Difficulty was experienced in achieving patient follow up via automated recall systems, or when follow up involved multiple staff. Hospital staff flagged issues particular to its service,
including the high use of locum staff, shorter GP consultation times and the fact that the general practice was staffed by a rotating roster. Hospital staff in the ED found screening challenging in the context of its unpredictably busy periods. Neither service adopted POC HbA1c testing at the time, at one service because it was unavailable and at the other due to concerns about its cost and accuracy.

Discussion
This is the first study to review the implementation of a T2D screening algorithm for 10- to 14-year-old Aboriginal Australians. It provides new insights into the particular challenges associated with T2D screening in adolescents, and affirms previously reported findings regarding enablers and barriers to implementation of a T2D guideline in a remote setting (Marley et al. 2016).

Apprehension about T2D screening in young adolescents affected every step of the screening process in this study, with healthcare practitioners often reluctant to follow recommendations outlined in the algorithm. In assessing whether a patient was at high risk, for example, audit and interview data showed a focus on obesity, with minimal consideration for other risk factors. Second, several staff were unwilling to perform POC or venous tests due to a belief they may cause unnecessary pain to their patients. Finally, only a small proportion of patients received follow-up venous testing when indicated. A reluctance on the part of clinicians to proceed to venous testing was apparent in the number of patients with a POC BGL ≥5.5 mmol L⁻¹ ranging up to 10 mmol L⁻¹, who were advised to come back for testing at a later date or received no further follow up. Deferring venous tests to a future visit generally resulted in missed screening opportunities, as the majority of patients did not re-present or were not tested when they did. Similarly, locum staff demonstrated an unwillingness to screen adolescents in accordance with regional guidelines that differed from routine practice in an urban setting.

A comparison of screening at the participating services suggests organisational culture and characteristics can facilitate screening. Implementation of the algorithm was more effective at the ACCHS, where the proportion of 10- to 14-year-olds screened for T2D increased by over 50% (P = 0.011), and where patient notes indicated ACCHS GPs more frequently considered a need for screening. By contrast, audit data showed low rates of screening at the hospital with no improvement in the pilot. It is likely that more screening occurred at the hospital than was indicated by our audit, given ED presentations not transferred to electronic records could not be included in the audit. Of note, patients attending the hospital’s general practice clinic did not have routine observations taken by a nurse or AHW before their consult with a GP, whereas this was the most common reason for initial screening at the ACCHS. This was a significant learning point from this project and presents an opportunity moving forward for a greater focus on strengthening the integration of all staff and systems involved in the implementation of the guideline, with a particular emphasis on the role of AHWs and practice nursing staff. Other organisational factors like shorter general practice appointment times, the general practice being staffed by a rotating roster and a high reliance on locum staff, also appeared to contribute to less screening occurring at the hospital than at the ACCHS.

The results from this study provide insight into measures to improve T2D screening in Kimberley adolescents, which reflect similar findings of a review of the development and implementation of the updated Kimberley T2D guideline for adults aged ≥15 years (Marley et al. 2016). As with the adult guideline, a streamlined HbA1c-based screening algorithm for 10- to 14-year-olds could improve clinician uptake of screening and reduce uncertainty regarding follow up. This was evidenced in this study by the use of venous HbA1c testing during the pilot, compared with no venous testing during the pre-pilot when only fasting BGL or oral glucose tolerance testing was an option in the original algorithm. Simple algorithms are important in the remote context of the Kimberley region, where there is a high use of locum staff and streamlined regional approaches are desirable (Roach et al. 2007; Marley et al. 2016). Targeted risk-factor-based screening programs could familiarise patients and staff with T2D screening and improve consistency in clinical practice. Patient and staff education on risk factors, the importance of early diagnosis and evidence for the BGL and HbA1c testing thresholds, could allay patient and healthcare practitioner concerns about T2D screening in an adolescent demographic. Strong leadership and clinical governance, and human resource management practices that promote orientation of new clinical staff and a reduced reliance on short-term locums, would encourage effective implementation of a new algorithm and associated clinical practices across an organisation (Box 3).

Finally, it is significant that neither PHC service adopted POC HbA1c testing during this study; at the hospital because it was not available, and at the ACCHS because of concerns about its reliability. The ACCHS has since purchased new POC HbA1c testing equipment, partly in response to feedback from this and other studies. In an adolescent context, POC HbA1c testing could abate concerns about performing unnecessary venous tests, by enabling confirmation of an elevated POC BGL before proceeding to venous testing. In contrast to a POC BGL, a POC

Box 3. Recommendations to overcome barriers to screening

- Simplification of the algorithm.
- Removal of the blood glucose level (BGL) pathway, suggested by clinicians in the interviews and supported by data indicating that glycated haemoglobin (HbA1c) tests were preferred during the pilot.
- Implementing risk-factor-targeted screening programs, supported by the low proportion of patients screened for risk factors.
- Education regarding risk factors, the importance of early diagnosis and evidence for the BGL and HbA1c testing thresholds.
- Improving healthcare practitioner confidence and proficiency using POC HbA1c testing.
HbA1c result should not be affected by daily variables such as the patient’s diet or health on the day of presentation. Use of POC HbA1c would further allow screening POC tests and diagnostic venous tests to be conducted in a single patient visit, a factor that has been shown to improve diagnosis of T2D in Kimberley adults (Marley et al. 2015; Marley et al. 2016).

This was a small study piloting a change to T2D screening approaches in young people and was primarily focussed on clinical staff initiating screening, who were mostly non-Aboriginal at the time of this study. Unfortunately, it did not capture the important perspective of AHWs who, although invited, were not in attendance at the ACCHS interviews. Other limitations include its small patient sample size, with only two participating PHC services, and incomplete hospital data given only electronic data could be included in the audit. The study was not designed to address whether an increase in screening would lead to more patients being diagnosed with T2D, which would require a significantly larger sample size. It also did not address management, which is being considered as part of the ongoing KIDDY project, and which participating PHC services undertake in accordance with the existing Kimberley T2D guidelines and their chronic disease programs (KAMS and WACHS 2011, 2015).

Conclusion
This study demonstrates complex screening guidelines and PHC staff apprehension about screening in young people pose two key challenges to implementing a T2D screening algorithm in adolescents in busy real-world PHC settings. Importantly, it offers new ideas to inform review of the algorithm for the Kimberley T2D guideline for Aboriginal Australians aged 10–14 years, and insight into factors underlying its successful implementation. These include a simplified screening algorithm, risk-based targeted screening programs, education for patients and healthcare practitioners, use of POC HbA1c testing and a whole-of-clinic approach to implementation.

Conflicts of interest
The authors declare no conflicts of interest.

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